CLAIMS

What is claimed is:

1. An apparatus, comprising:

a gain medium disposed in a semiconductor substrate;

a tunable Bragg grating disposed in the semiconductor substrate, the tunable Bragg grating optically coupled to the gain medium so as to tune an output wavelength of an optical beam generated from the gain medium; and

an optical modulator disposed in the semiconductor substrate, the optical modulator optically coupled to receive the optical beam, the optical modulator to modulate the optical beam generated from the gain medium in response to a modulation signal.

2. The apparatus of claim 1 wherein the optical modulator comprises:

a first optical path through the semiconductor substrate through which a first portion of the optical beam is directed;

a second optical path through the semiconductor substrate through which a second portion of the optical beam is directed;

first and second optical phase adjusting devices disposed in a semiconductor substrate in the first and second optical paths, respectively, the first and second optical phase adjusting devices to selectively adjust a phase difference between the first and second portions of the optical beam in response to phase adjustment signals;

an optical confinement region disposed in the semiconductor substrate between the first and second optical paths so as to optically isolate the first optical path from the second

optical path until the first and second optical paths are merged in the semiconductor substrate.

3. The apparatus of claim 2 wherein the first and second phase adjusting devices each include a plurality of charge modulated regions disposed in the semiconductor substrate along the first and second optical paths, respectively.

4. The apparatus of claim 2 wherein the first and second phase adjusting devices each include an array of trench capacitors disposed in the semiconductor substrate along the first and second optical paths, respectively.

5. The apparatus of claim 1 wherein the gain medium comprises a diode disposed in the semiconductor substrate.

6. The apparatus of claim 1 wherein the gain medium comprises an InP diode disposed in the semiconductor substrate.

7. The apparatus of claim 1 wherein the gain medium and the tunable Bragg grating together form a tunable laser disposed in the semiconductor substrate, wherein an optical coupling between the gain medium and the tunable Bragg grating define a laser cavity disposed in the semiconductor substrate.

8. The apparatus of claim 1 wherein the tunable Bragg grating comprises a plurality of perturbations of a refractive index of the semiconductor substrate.

9. The apparatus of claim 8 wherein the plurality of perturbations of the refractive index of the semiconductor substrate are provided with periodic regions of silicon and polysilicon disposed in the tunable Bragg grating in the semiconductor substrate.

10. The apparatus of claim 8 wherein the plurality of perturbations of the refractive index of the semiconductor substrate are provided with periodic changes in a geometry in the tunable Bragg grating of the semiconductor substrate.

11. The apparatus of claim 8 wherein the tunable Bragg grating further comprises a heater disposed proximate to the semiconductor substrate of the tunable Bragg grating, the refractive index of the semiconductor substrate responsive to a temperature in the tunable Bragg grating of the semiconductor substrate.

12. The apparatus of claim 8 wherein the tunable Bragg grating further comprises a electrodes disposed in the semiconductor substrate of the tunable Bragg grating to modulate a charge concentration in the semiconductor substrate, the refractive index of the semiconductor substrate responsive to the charge concentration in the tunable Bragg grating in the semiconductor substrate.

13. The apparatus of claim 1 further comprising a multiplexer disposed in the semiconductor substrate, the multiplexer optically coupled to an output of the optical modulator so as to multiplex the optical beam generated from the gain medium with a plurality of other optical beams.

14. The apparatus of claim 1 further comprising an optical splitter disposed in the semiconductor substrate, the optical splitter optically coupled to receive the optical beam, the optical splitter to split the optical beam into a plurality of optical beams.

15. The apparatus of claim 14 wherein the tunable Bragg grating is a first tunable Bragg grating of a plurality of Bragg gratings disposed in the semiconductor substrate, each of the plurality of Bragg gratings optically coupled to the optical splitter to receive a respective one of the plurality of optical beams, each of the plurality of Bragg gratings to tune a respective output wavelength of the respective one of the plurality of optical beams.

16. The apparatus of claim 15 wherein the optical modulator is a first optical modulator of a plurality of optical modulators disposed in the semiconductor substrate, each of the optical modulators optically coupled to a respective one of the plurality of tunable Bragg gratings to modulate the respective one of the plurality of optical beams.

17. The apparatus of claim 1 wherein the gain medium is disposed in the semiconductor substrate between the tunable Bragg grating and the optical modulator.

18. The apparatus of claim 1 wherein the tunable Bragg grating is disposed in the semiconductor substrate between the gain medium and the optical modulator.

19. A method, comprising:

generating an optical beam with a gain medium disposed in a semiconductor substrate;

tuning an output wavelength of the optical beam with a tunable Bragg grating disposed in the semiconductor substrate optically coupled to the gain medium; and

modulating the optical beam with an optical modulator disposed in the semiconductor substrate in response to a modulation signal.

20. The method of claim 19 wherein the tunable Bragg grating is a first one of a plurality of Bragg gratings disposed in the semiconductor substrate, wherein the optical modulator is a first one of a plurality of optical modulators disposed in the semiconductor substrate, the method further comprising:

splitting the optical beam generated by the gain medium into a plurality of optical beams with an optical splitter disposed in the semiconductor substrate;

tuning an output wavelength of each of the plurality of optical beams with a respective one of a plurality of tunable Bragg gratings disposed in the semiconductor substrates optically coupled to receive a respective one of the plurality of optical beams; and

modulating each of the plurality of optical beams with a respective one of a plurality of optical modulators disposed in the semiconductor substrate in response to modulation signals.

21. The method of claim 19 wherein modulating the optical beam with the optical modulator disposed in the semiconductor substrate comprises:

directing a first portion of the optical beam through a first path of the optical modulator in the semiconductor substrate;

directing a second portion of the optical beam through a second path of the optical modulator in the semiconductor substrate;

selectively adjusting a phase difference between the first and second portions of the optical beam in response to the modulation signal with a first and second phase adjusting devices disposed in the first and second optical paths of the optical modulator;

optically isolating the first and second optical paths; and

merging the first and second optical paths to combine the first and second portions of the optical beam.

22. The method of claim 19 wherein the optical beam is one of a plurality of optical beams that are generated, tuned and modulated in the semiconductor substrate, the method further comprising multiplexing the plurality of optical beams into a single wave division multiplexed (WDM) optical beam with a multiplexer disposed in the semiconductor substrate.

23. The method of claim 19 wherein tuning the tuning the output wavelength of the optical beam with the tunable Bragg grating disposed in the semiconductor substrate comprises adjusting a temperature of the semiconductor substrate including the tunable Bragg grating.

24. The method of claim 19 wherein tuning the tuning the output wavelength of the optical beam with the tunable Bragg grating disposed in the semiconductor substrate comprises adjusting a concentration of charge in the semiconductor substrate including the tunable Bragg grating.

25. An optical communications system, comprising:

an optical transmit module disposed in a semiconductor substrate, the optical transmit module including:

a gain medium disposed in the semiconductor substrate;

a tunable Bragg grating disposed in the semiconductor substrate, the tunable Bragg grating optically coupled to the gain medium so as to tune an output wavelength of a optical beam generated from the gain medium; and

an optical modulator disposed in the semiconductor substrate, the optical modulator optically coupled to receive the optical beam, the optical modulator to modulate the optical beam generated from the gain medium in response to a signal;

a multiplexer optically coupled to receive the a plurality of optical beams generated in the semiconductor substrate, wherein the optical beam generated from the gain medium is one of the plurality of optical beams generated in the semiconductor substrate, the multiplexer to multiplex the plurality of optical beams into a single wave division multiplexed (WDM) optical beam;

a demultiplexer optically coupled to receive the WDM optical beam through an optical fiber, the demultiplexer to demultiplex the WDM optical beam back into the plurality of optical beams; and

a plurality of optical receivers, each of the optical receivers optically coupled to receive a respective one of the plurality of optical beams.

26. The optical communications system of claim 25 wherein the gain medium is one of a plurality of gain mediums disposed in the semiconductor substrate, each one of the

plurality of gain mediums generating a respective one of the plurality of optical beams generated in the semiconductor substrate, the tunable Bragg grating one of a plurality of tunable Bragg gratings disposed in the semiconductor substrate, each one of the plurality of tunable Bragg gratings optically coupled to a respective one of the plurality of gain mediums so as to tune a respective output wavelength of the respective one of the plurality of optical beams, the optical modulator one of a plurality of optical modulators disposed in the semiconductor substrate, each one of the plurality of optical modulators optically coupled to a respective one of the plurality of optical beams so as to modulate the respective one of the plurality of optical beams in response to a respective modulation signal.

27. The optical communications system of claim 25 wherein the optical transmit module further includes an optical splitter optically coupled to split the optical beam generated from the gain medium into the plurality of optical beams generated in the semiconductor substrate, the tunable Bragg grating one of a plurality of tunable Bragg gratings disposed in the semiconductor substrate, each one of the plurality of tunable Bragg gratings optically coupled to a respective one of the plurality of optical beams from the optical splitter so as to tune a respective output wavelength of the respective one of the plurality of optical beams, the optical modulator one of a plurality of optical modulators disposed in the semiconductor substrate, each one of the plurality of optical modulators optically coupled to a respective one of the plurality of optical beams so as to modulate the respective one of the plurality of optical beams in response to a respective modulation signal.

28. The optical communications system of claim 25 wherein the multiplexer is included in the optical transmit module in the semiconductor substrate.

29. The optical communications system 25 wherein the optical modulator in the semiconductor substrate of the optical transmit module comprises:

a first optical path through the semiconductor substrate through which a first portion of the optical beam is directed;

a second optical path through the semiconductor substrate through which a second portion of the optical beam is directed;

first and second optical phase adjusting devices disposed in a semiconductor substrate in the first and second optical paths, respectively, the first and second optical phase adjusting devices to selectively adjust a phase difference between the first and second portions of the optical beam in response to phase adjustment signals;

an optical confinement region disposed in the semiconductor substrate between the first and second optical paths so as to optically isolate the first optical path from the second optical path until the first and second optical paths are merged in the semiconductor substrate.

30. The optical communications system of claim 25 wherein the tunable Bragg grating in the semiconductor substrate of the optical transmit module comprises a plurality of perturbations of a refractive index of the semiconductor substrate.